
State of California
The Resources Agency
Department of Water Resources

**FINAL REPORT
EVALUATION OF INTERACTIONS BETWEEN
THE LAKE OROVILLE FISHERY AND UPSTREAM
TRIBUTARY FISHERIES
SP-F5/7 TASK 3**

**Oroville Facilities Relicensing
FERC Project No. 2100**



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REPORT SUMMARY

The purpose of SP-F5/7 Task 3 was to evaluate potential interactions between the Lake Oroville fishery and fisheries in the tributaries upstream from Lake Oroville. The Oroville Facilities have the potential to influence fish species interactions between the two fisheries as a result of reservoir surface elevation fluctuations caused by project operations and the maintenance of both a warmwater and coldwater fishery in Lake Oroville. When the surface elevation of Lake Oroville is high, fish are able to move freely between the lake and the tributaries. At low reservoir surface elevations, passage between the fisheries may be blocked. The results of this study provide information regarding the potential interactions among fish species of the two fisheries including, competition for food and habitat, predation, disease transmission, and genetic introgression. Additionally, the results of this study will be used to evaluate particular resource actions that may affect connectivity between the two fisheries or species composition in either Lake Oroville or the upstream tributaries.

Fish species composition in the tributaries upstream from Lake Oroville was determined by surveys and literature review conducted for SP-F3.1 Task 1B, while fish species composition in Lake Oroville was determined as part of SP-F1 Task 2A. Potential interactions between the two fish species assemblages were identified as competition for food and habitat, predation, disease transmission, and genetic introgression. A review of available fisheries literature was conducted to provide a conceptual evaluation of the potential effects of these interactions.

Lake Oroville is managed as a two-story fishery composed of both warmwater and coldwater fish species. The warmwater fishery is self-sustaining and is primarily made up of four species of black bass, two species of catfish, two species of sunfish, and two species of crappie. The coldwater fishery is maintained through stocking. Inland coho salmon (*Oncorhynchus kisutch*), Chinook salmon (*O. tshawytscha*), brown trout (*Salmo trutta*), rainbow trout (*O. mykiss*), brook trout (*Salvelinus fontinalis*), kokanee salmon (*O. nerka*) and lake trout (*Salvelinus namaycush*) have been stocked at various times in the past. According to DWR (2003c) lake trout were last stocked prior to 1993, Chinook salmon and brown trout were stocked last in 2000. Coho salmon were last stocked in 2003. According to FERC (2004) only coho salmon were to be stocked through the end of the current FERC license and stocking activities subsequent to 2006 were to be determined in the new Oroville Facilities FERC license. Due to a disease outbreak in the coho salmon brood hatchery in Washington, and NOAA Fisheries concerns regarding importation to the Feather River watershed of out-of-basin fish, no stocking activities took place in Lake Oroville during 2004. However, NOAA Fisheries agreed to allow DWR to stock coho salmon again in 2005 if all stocked fish were tagged with coded wire tags. Tributaries upstream from Lake Oroville are managed as a coldwater salmonid fishery consisting primarily of rainbow trout (*Oncorhynchus mykiss*) and brown trout. Surveys conducted by DWR during 2002 and 2003 did not detect coho salmon in any of the survey reaches in the upstream tributaries, however redeye bass (*Micropterus punctulatus*), spotted bass (*M. punctulatus*), and smallmouth bass (*M.*

dolomieu) were observed in the lower reaches of the Middle Fork Feather River while spotted bass also were observed in the South Fork Feather River. Surveys conducted by PG&E prior to 2000 also observed smallmouth bass in the North Fork Feather River. Additionally, one largemouth bass (*M. salmoides*) was observed in the lower reaches of the North Fork Feather River by a PG&E survey in 1992. Black bass are considered warmwater species and typically utilize different habitat types during all life stages than salmonids. Therefore, it is unlikely that competition for habitat between these two species assemblages would have any adverse effects on either assemblage. However, spotted bass reportedly utilize similar riverine habitat to brown trout. Thus, competition for habitat among some members of the species assemblages could occur. Food resources in tributaries upstream from Lake Oroville reportedly are not limiting. Therefore, competition for food is not likely to have adverse effects on any species present. Black bass species are piscivores and some level of predation on juvenile salmonids may exist from bass moving into upstream tributaries, particularly from spotted bass because they reportedly tend to migrate from reservoirs into tributary streams. Chinook salmon stocking in Lake Oroville was halted after 2000 and coho salmon stocking was temporarily halted after 2003. However, because these fish were not observed in upstream tributaries below the first passage barrier during the time period when stocking occurred, interactions with other salmonid species likely were, and likely would continue to be minimal. Coho salmon and Chinook salmon are not known to hybridize with rainbow trout or brown trout, therefore genetic introgression between stocked fish and resident species likely had no effect on resident species during periods when coho salmon and Chinook salmon were stocked, and likely would have no effect if either species were stocked in the future. Stocked Lake Oroville brown trout and rainbow trout could interbreed with resident trout species in the upstream tributaries causing genetic introgression if stocked fish were from out-of basin genetic sources.

Based on available survey data and a review of available fisheries literature, it does not appear likely that current fisheries management practices or current project operations are likely to cause interactions between fish species assemblages in Lake Oroville and its upstream tributaries that are likely to negatively affect either of the species assemblages. However, management practices that include stocking rainbow or brown trout in Lake Oroville could potentially affect resident populations in the upstream tributaries.

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1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

The Oroville Facilities have the potential to influence fish species interactions between the fishery in Lake Oroville and the fishery in Lake Oroville's upstream tributaries as a result of reservoir surface elevation fluctuations coupled with the maintenance of both a warmwater and coldwater fishery in Lake Oroville. When Lake Oroville is at high water surface elevation fish are able to move freely between the lake and the tributaries, while at low reservoir surface elevations passage between the fisheries may be blocked. As a component of study plan (SP)-F5/7, *Evaluation of Fisheries Management on Project Fisheries*, Task 3, herein, evaluates the interactions between the Lake Oroville fishery and the upstream tributary fisheries.

1.1.1 Statutory/Regulatory Requirements

Section 4.51(f)(3) of 18 CFR requires reporting of certain types of information in the Federal Energy Regulatory Commission (FERC) application for license of major hydropower projects, including a discussion of the fish, wildlife, and botanical resources in the vicinity of the project (FERC 2001). The discussion is required to identify the potential impacts of the project on these resources, including a description of any anticipated continuing impact from on-going and future operations. As a subtask of SP-F5/7, Task 3 fulfills a portion of the FERC application requirements by detailing potential effects of project operations on fish species interactions between the Lake Oroville and upstream tributary fisheries.

1.1.2 Study Area

The study area for Task 3 of SP-F5/7 includes Lake Oroville and the four major tributaries of the Feather River extending upstream from the high water mark of Lake Oroville to the first stream channel obstructions that, under normal flow conditions, limit the upstream migration of salmonids. The tributaries include the North Fork Feather River (North Fork) upstream to Poe Dam, West Branch North Fork Feather River (West Branch) upstream to Miocene Dam, Middle Fork Feather River (Middle Fork) upstream to Curtain Falls, and the South Fork Feather River (South Fork) upstream to Ponderosa Dam. Smaller tributaries in the study area include Berry Creek, Canyon Creek, Chino Creek, Concow Creek, Fall River, French Creek, Frey Creek, Sucker Run Creek, McCabe Creek, and Stony Creek. The study area is shown in Figure 1.1-1.

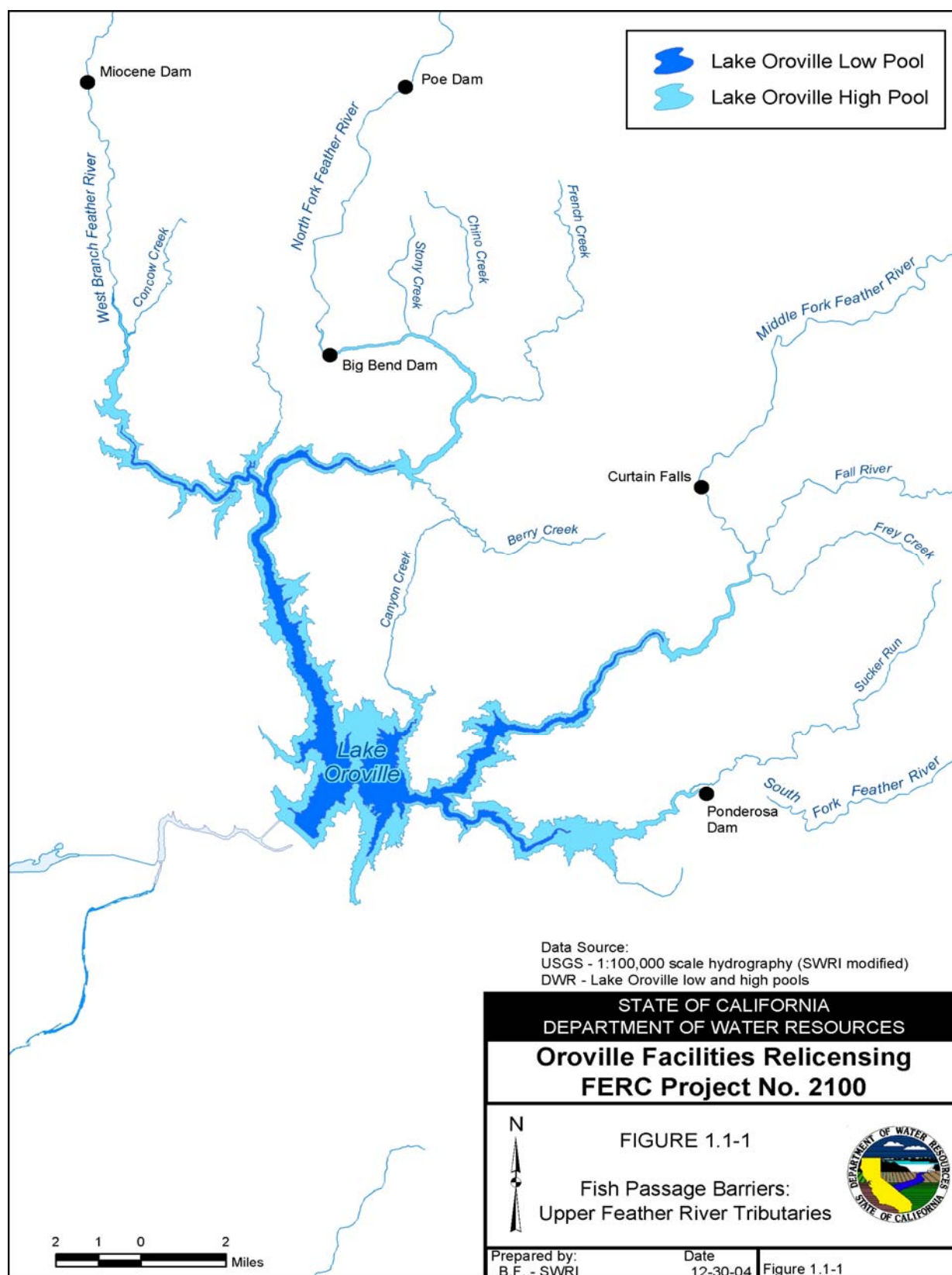


Figure 1.1-1 Lake Oroville and Upstream Tributaries

1.1.2.1 Description

The upper Feather River watershed (drainage area above the gauging station at Oroville) drains 3,624 square miles and encompasses about 68 percent of the Feather River basin (DWR 2001). Four major tributaries drain the upper Feather River watershed upstream from Lake Oroville including the West Branch, the North Fork, the Middle Fork, and the South Fork.

Lake Oroville

Construction of Oroville Dam was completed in 1968 as part of the State Water Project (SWP) and currently impounds Lake Oroville. Lake Oroville has a storage capacity of 3,538,000 acre-feet and is fed by the four major tributaries of the Feather River. The water surface elevation and water surface area at maximum operating storage are 900 feet above mean sea level (msl) and 15,810 acres, respectively. The shoreline covers 167 miles (DWR 2001).

In general, Lake Oroville thermally stratifies in the spring, destratifies in the fall, and remains destratified throughout the winter. Lake Oroville supports a two-story fishery, which means that it supports both coldwater and warmwater fish species that are thermally segregated for most of the year. The coldwater fish use the deeper, cooler, well-oxygenated hypolimnion, whereas the warmwater fish are found in the warmer, shallower, epilimnetic and littoral zones. When Lake Oroville destratifies, the two fishery components mix in their habitat utilization. Currently no coldwater fish are stocked in the reservoir. The Lake Oroville coldwater fishery, under the stocking program approved by FERC (DWR 2003c; FERC 1994; FERC 2004) was prior to 2003, and would be through 2006, managed as a put and grow fishery, meaning that hatchery raised fish are stocked in Lake Oroville as juveniles, with the intent that they will grow in the lake before being caught by anglers. The California Department of Fish and Game (DFG) manages the Lake Oroville coldwater fishery with the primary objectives of producing trophy salmonids and providing a quality fishery characterized by high salmonid catch rates (DWR 2001). The coldwater fishery is sustained by hatchery stocking because natural recruitment to the Lake Oroville coldwater fishery is low (DWR 2001). The current salmonid fishery is not self-sustaining, possibly due to insufficient spawning and rearing habitat in the reservoir and accessible tributaries, and natural and artificial barriers to migration into the upstream tributaries with sufficient spawning and rearing habitat. The Lake Oroville warmwater fishery is a regionally important self-sustaining recreational fishery.

Water surface elevation fluctuations in Lake Oroville occur on a seasonal basis, resulting from seasonal variations in upstream tributary inflows into the reservoir, as well as seasonal variations in Oroville Facilities reservoir releases. Reservoir stage elevation reductions as well as the rates of reductions can reduce the amount of littoral fish habitat, invertebrate recruitment as a food base, and the quantity of coldwater

fishery habitat. Additionally, reservoir stage fluctuations may affect connectivity to upstream tributaries.

West Branch North Fork Feather River

The upstream extent of the study area flows from Miocene Dam at an elevation of 1,550 feet msl to the high pool level of Lake Oroville at 900 feet msl, a distance of approximately six river miles. Miocene Dam is a concrete diversion dam located approximately 3 to 4 river miles upstream from Salmon Falls. It may be possible, during extremely high flow events, that Miocene Dam would become passable allowing access to another four river miles of habitat upstream to the falls below Big Kimsheew Creek. The Falls below Big Kimsheew Creek are located approximately $\frac{3}{4}$ mile downstream from Big Kimsheew Creek and are estimated to be 5 to 6 meters in height. Another potential upstream migration barrier is Salmon Falls. Salmon Falls, along with other potential migration barriers, was evaluated as a potential upstream migration barrier during the SP 3.1 Task 1A data gathering process. Although not evaluated at all potential flows, the assessment team concluded that Salmon Falls presents a likely barrier to upstream migration during all but extreme flow events (DWR 2004a). Concow Creek is a major tributary flowing into the West Branch downstream from the high pool level of Lake Oroville.

North Fork Feather River

Big Bend Dam marks the upstream extent of the study area on the North Fork and is at the same elevation as the high pool level of Lake Oroville. During high flow events when Lake Oroville is at full pool (normally in the spring) it is likely that Big Bend Dam is passable (DWR 2004a; DWR 2004b). Big Bend Dam is a concrete dam located approximately $\frac{1}{2}$ river mile downstream from Poe Powerhouse. The dam crosses the entire river channel and passes water over its top during high flow conditions. When Big Bend Dam is passable, the upstream extent of habitat would extend to Poe Dam. Major tributaries of the North Fork Feather River downstream from Big Bend Dam include Stony Creek, Chino Creek, French Creek, and Berry Creek.

Middle Fork Feather River

The upstream extent of the study area on the Middle Fork Feather River is Curtain Falls at an elevation of 1,220 feet msl. Curtain Falls is located approximately six river miles upstream from the high pool level of Lake Oroville. Major tributaries of the Middle Fork include Fall River, Frey Creek, and Canyon Creek. The Middle Fork has been designated a "Wild and Scenic River."

The Wild and Scenic Rivers Act of 1968 (PL-542, 16 USC 1271-1287) established the policy that certain rivers and their immediate environments, which possess outstanding scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values will be preserved and protected. Section 10 of the act requires that each component of

the Wild and Scenic river system be administered in such a manner as to protect and enhance the values for which the river was designated. Under this act, federal agencies with discretionary decision-making authority (i.e., permitting authority) must review the proposed project in relation to Section 7 and Section 10 of the act to determine if the proposed project would affect the values of the Wild and Scenic river. The Middle Fork was one of the nine original rivers designated under the act in 1968. The designation includes the entire Middle Fork downstream from the confluence of its tributary streams one kilometer south of Beckwourth, California (U.S. Congress 1968). The 77.6 miles of stream included in this description are broken down according to their classification statute: 32.9 miles are designated as wild, 9.7 miles are managed as scenic, and 35 miles are managed for recreational purposes (National Park Service Website 2004). The Secretary of Agriculture administers the Middle Fork Feather River component of the National Wild and Scenic Rivers System.

The Fish and Game Commission also has designated the Middle Fork to be managed exclusively for wild trout. The Fish and Game Commission established the California Wild Trout Program in 1971, with an objective of protecting and enhancing fisheries sustained by strains of trout. The waters managed by the Fish and Game Commission include lakes and streams, which are designated as either Catch-and Release and/or Wild Trout streams. The Fish and Game Commission set forth a policy, which states: "all necessary actions, consistent with State law, shall be taken to prevent adverse impact by land or water development projects affecting designated wild trout rivers." It is the responsibility of DFG, through the Wild Trout Program, to implement the Trout and Steelhead Conservation and Management Planning Act of 1979, which requires annual statewide inventories of trout streams and lakes, evaluations of catch-and-release regulations, and recommends waters for catch-and-release angling regulations. The Middle Fork Feather River is one of the original streams included in the Wild Trout Program, and is designated as a wild trout river (DFG Website 2004). Trout for which the Middle Fork Feather River is managed include rainbow and brown trout.

South Fork Feather River

Ponderosa Dam marks the upstream extent of the study area on the South Fork. Ponderosa Dam is a large earth-fill dam near the full-pool level of Lake Oroville. The dam has a concrete spillway on river-right, which serves as a straight, high velocity chute ending in a waterfall. Major tributaries of the South Fork downstream from Ponderosa Dam, within the high-pool level of Lake Oroville include Sucker Run Creek and McCabe Creek.

1.1.2.2 History

Historically, the upper Feather River watershed provided habitat for anadromous and resident salmonids. Spring-run Chinook salmon and steelhead were reported to ascend the very highest streams and headwaters of the Feather River watershed, while fall-run Chinook salmon occupied the lower foothill reaches of the river (DWR and USBR 2000;

Yoshiyama et al. 1998). Prior to the construction of Oroville Dam, the upstream extent of fish passage was limited by natural fish barriers and previously constructed hydroelectric projects.

DFG has been involved with fisheries management activities in the Feather River watershed for over 100 years. In the 1960s, DFG narrowed its focus from the watershed level and initiated fisheries management activities within the FERC-project boundary. Management activities included fisheries studies, species introductions, fish stocking programs, habitat enhancement projects, and operation of the Feather River Fish Hatchery (FRFH). While habitat restoration efforts and stocking from the FRFH have increased fish production and provided increased angling opportunities in Lake Oroville, management actions such as the introduction of exotic species, as well as natural processes such as disease propagation may have affected fisheries resources in project waters.

As a result of a 1994 FERC order, DWR became involved with fisheries management activities within the FERC project boundary. Since that time, DWR has stocked over 1.9 million Chinook salmon in Lake Oroville and expanded the Feather River Hatchery to accommodate Lake Oroville stocking. In 1999 alone, the Feather River Hatchery raised approximately 500,000 yearling Chinook salmon, 25,000 of which were stocked in the Thermalito Forebay, 158,000 were placed in Lake Oroville (in addition to 128,750 fingerlings), and the remainder were stocked in reservoirs outside the Oroville area.

The literature search identified a variety of different salmonid species, strains, and sizes that have been stocked in Lake Oroville since its creation in 1968. During Lake Oroville's first decade, rainbow trout, brown trout, and coho salmon were the primary species being stocked, with periodic plants of kokanee salmon. Catchable-sized (10-12 inches long) fish were emphasized, which provided immediate angler returns in addition to larger trophy-sized fish if they survived over the winter and were available for a second and even third year in the lake. As is common with newly created reservoirs, fish growth was very high and Lake Oroville quickly became one of the most popular reservoir fisheries in California for all four of these species (John Hiscox pers. comm. 1993). In 1972, DFG introduced wakasagi smelt into Lake Almanor to provide a forage base for the Almanor coldwater fishery. Lake Almanor is located upstream of Lake Oroville on the North Fork of the Feather River, and by 1976 the wakasagi had passed down into Lake Oroville where they became established (Moyle 2002). They directly competed with the kokanee salmon in Lake Oroville since they both feed primarily on zooplankton in the cooler, deeper waters. This competition reduced the kokanee growth rate to a point where DFG ceased stocking kokanee after 1977 and this program has never been revived.

During Lake Oroville's second decade, rainbow trout stocking was phased out due to decreasing angler returns as a result of the presence of *Ceratomyxa shasta*, a myxosporean parasite that is lethal to most varieties of rainbows, and competition with wakasagi smelt (DWR 1993). Coho stocking was reduced due to egg supply and

hatchery rearing problems (DWR 1993). The stocking of catchable-sized brown trout was increased, and Chinook salmon stocking became a regular occurrence, both at the fingerling (3-4 inches long) and yearling (6-8 inches long) size ranges. DFG experimented with lake trout, but this was abandoned due to egg supply difficulties and concerns that lake trout may compete or predate on the lake's warmwater fisheries.

By the beginning of the 1990s, brown trout and Chinook salmon had become the dominant coldwater species stocked in Lake Oroville, and except for a small group of coho salmon fingerlings stocked by a private fishing organization in 1991, this continued throughout the decade. Catchable-sized fish were phased out as the stocking management shifted toward a "put-and-grow" type of program, where smaller hatchery-produced salmonids (3-8 inches long) are stocked with the anticipation that they will increase substantially in size and survive for more than one season. DFG and DWR conducted a fishery study from 1993 through 1999, to update the fishery management plan and establish optimum stocking rates for the lake. Chinook yearlings were stocked in increasing amounts each year for several consecutive years to study the effects this would have on Chinook growth. The baseline amount of Chinook yearlings was 60,000/year, and this was increased to 350,000/year in the fifth year of the study. During this same period, the numbers of Chinook fingerlings was about 100,000/year, and brown trout averaged about 60,000/year. DFG set minimum growth criteria for the Chinook salmon of 13 inches at 18 months of age, and 16 inches at 24 months of age. This growth criteria was met until the stocking exceeded 170,000 yearlings per year, so ultimately this stocking level was recommended for Chinook salmon at Lake Oroville (DWR 2000). Although the angler catch of brown trout were very low (DWR 2000), DFG decided to continue stocking brown trout because their presence provided additional angler interest in the Lake Oroville fishery.

Prior to the involvement of DWR in the management of the fisheries within the project area, DFG had conducted several fish stocking experiments. In the 1970s and 1980s DFG stocked rainbow trout and lake trout in Lake Oroville with limited success (DWR 2001). Rainbow trout are still caught in Lake Oroville in low numbers. Private fishing clubs also stocked Florida-strain largemouth bass (*M. salmoides floridanus*), white crappie (*Pomoxis annularis*), white sturgeon (*Acipenser transmontanus*), and Sacramento perch (*Archoliptes interruptus*) in Lake Oroville, with limited success as well.

The current Lake Oroville stocking program goal is to annually stock approximately 170,000 coho salmon in order to provide a satisfactory coldwater fishery. This recent program developed as a result of a severe outbreak of Infectious Hematopoietic Necrosis (IHN) virus in the FRH that began in 2000, and was traced back to the presence of IHN in Lake Oroville salmonids. Lake Oroville forms the water supply for the FRH and DFG was concerned that diseased fish in the lake could infect the hatchery. Therefore, DFG issued a moratorium on stocking any salmonids in Lake Oroville until they completed testing on the IHN susceptibility of various salmonid species and varieties. DFG found that Chinook salmon and brown trout, the two species

being stocked up to that time, were capable of transmitting IHN and therefore should no longer be stocked in the lake. DFG found that coho salmon were resistant to IHN and recommended that they be stocked to provide for the Lake Oroville coldwater fishery (DFG 2000). In late 2001, DWR located a private aquaculture facility in Washington State (Aquaseed Corporation) that could be used as a source for coho salmon eggs, and subsequently stocked 178,529, and 172,792 coho salmon in 2002 and 2003, respectively. Coho were scheduled for stocking during 2004, however DFG did not allow the importation of the Aquaseed coho eggs because they failed DFG's disease certification process due to a bacterial disease (*Renibacterium*) that was found in some of Aquaseed's broodstock. Subsequently, DFG advised Aquaseed on better procedures to address the *Renibacterium* problem, and it is anticipated that coho stocking will resume in 2005. The coho stocking levels have loosely been based upon those for Chinook salmon, however this may be adjusted somewhat as this new program is being implemented and more information becomes available.

1.2 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project (SWP), a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in northern California, the San Francisco Bay area, the San Joaquin Valley, and southern California. The Oroville Facilities are also operated for flood management, power generation, to improve water quality in the Delta, provide recreation, and enhance fish and wildlife.

FERC Project No. 2100 encompasses 41,100 acres and includes Oroville Dam and Reservoir, three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Power Plant, and Thermalito Pumping-Generating Plant), Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area (OWA), Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, and transmission lines, as well as a number of recreational facilities. An overview of these facilities is provided on Figure 1.2-1. The Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a 3.5-million-acre-feet (maf) capacity storage reservoir with a surface area of 15,810 acres at its normal maximum operating level.

The hydroelectric facilities have a combined licensed generating capacity of approximately 762 megawatts (MW). The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has a generating and pumping flow capacity of 16,950 cfs and 5,610 cfs, respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Power Plant and the 114-MW Thermalito Pumping-Generating Plant.

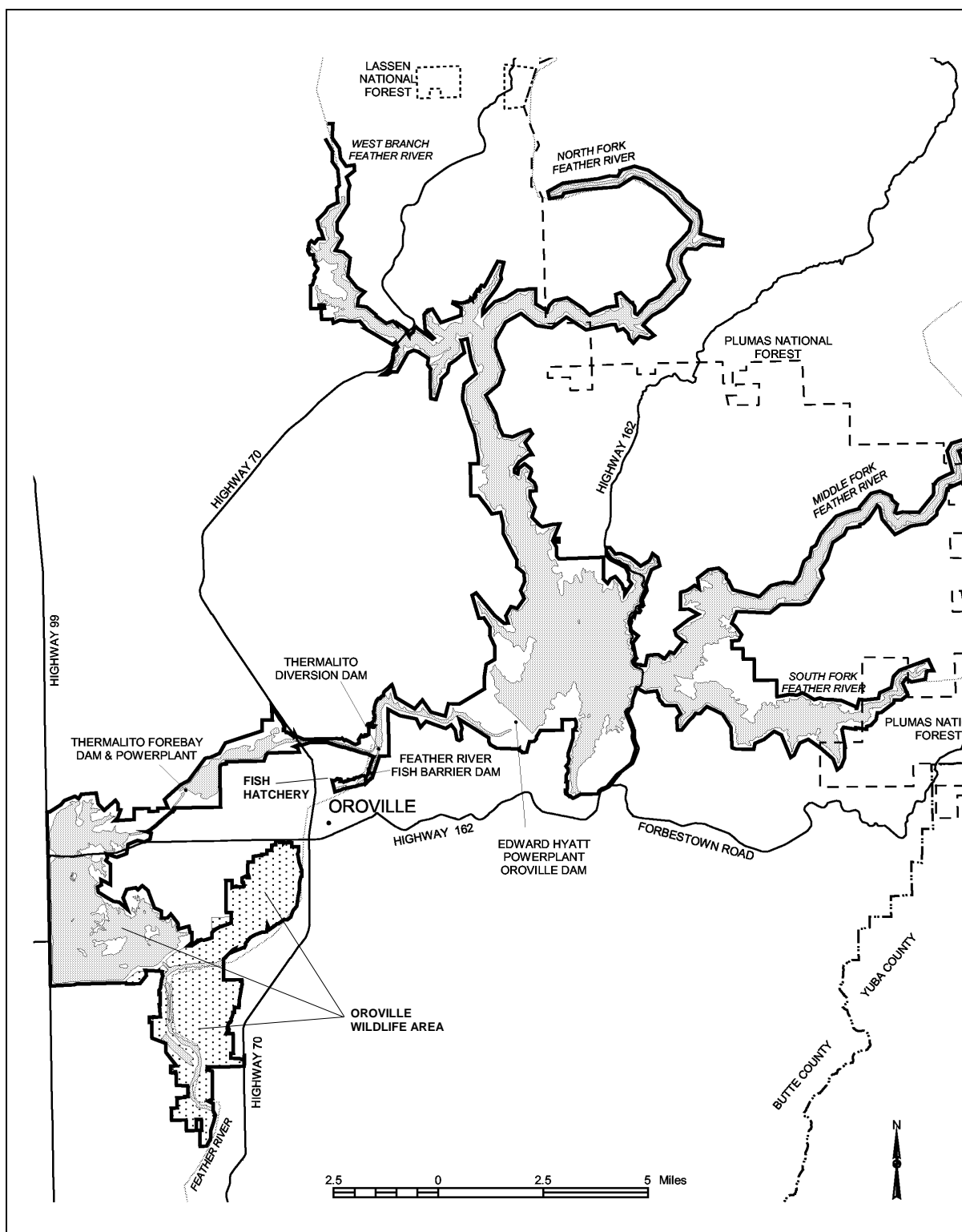


Figure 1.2-1. Oroville Facilities FERC Project Boundary.

Thermalito Diversion Dam, four miles downstream of the Oroville Dam creates a tail water pool for the Hyatt Pumping-Generating Plant and is used to divert water to the

Thermalito Power Canal. The Thermalito Diversion Dam Power Plant is a 3-MW power plant located on the left abutment of the Diversion Dam. The power plant releases a maximum of 615 cubic feet per second (cfs) of water into the river.

The Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to the Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. The Thermalito Forebay is an off-stream regulating reservoir for the 114-MW Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in generating mode, the Thermalito Pumping-Generating Plant discharges into the Thermalito Afterbay, which is contained by a 42,000-foot-long earth-fill dam. The Afterbay is used to release water into the Feather River downstream of the Oroville Facilities, helps regulate the power system, provides storage for pump-back operations, and provides recreational opportunities. Several local irrigation districts receive water from the Afterbay.

The Feather River Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low-flow channel of the Feather River between the dam and the Afterbay outlet, and provides attraction flow for the hatchery. The hatchery was intended to compensate for spawning grounds lost to returning salmon and steelhead trout from the construction of Oroville Dam. The hatchery can accommodate an average of 15,000 to 20,000 adult fish annually.

The Oroville Facilities support a wide variety of recreational opportunities. They include: boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, hunting, and visitor information sites with cultural and informational displays about the developed facilities and the natural environment. There are major recreation facilities at Loafer Creek, Bidwell Canyon, the Spillway, North and South Thermalito Forebay, and Lime Saddle. Lake Oroville has two full-service marinas, five car-top boat launch ramps, ten floating campsites, and seven dispersed floating toilets. There are also recreation facilities at the Visitor Center and the OWA.

The OWA comprises approximately 11,000-acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes the Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the Feather River. The 5,000 acre area straddles 12 miles of the Feather River, which includes willow and cottonwood lined ponds, islands, and channels. Recreation areas include dispersed recreation (hunting, fishing, and bird watching), plus recreation at developed sites, including Monument Hill day use area, model airplane grounds, three boat launches on the Afterbay and two on the river, and two primitive camping areas. California Department of Fish and Game's (DFG) habitat enhancement program

includes a wood duck nest-box program and dry land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a number of locations.

1.3 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly and hourly, depending on hydrology and the objectives DWR is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, recreation, diversion and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, in-stream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations planning is conducted for multi-year carry over. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1,000,000 acre-feet (af); however, this does not limit draw down of the reservoir below that level. If hydrology is drier than expected or requirements greater than expected, additional water would be released from Lake Oroville. The operations plan is updated regularly to reflect changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum annual level of up to 900 feet above mean sea level (msl) in June and then can be lowered as necessary to meet downstream requirements, to its minimum level in December or January. During drier years, the lake may be drawn down more and may not fill to the desired levels the following spring. Project operations are directly constrained by downstream operational constraints and flood management criteria as described below.

1.3.1 Downstream Operation

An August 1983 agreement between DWR and DFG entitled, "Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife," sets criteria and objectives for flow and temperatures in the low flow channel and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between Thermalito Afterbay Outlet and Verona which vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period, except for flood management, failures, etc.; (3) requires flow stability during the peak of the fall-run Chinook spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the later spring/summer for shad and striped bass.

1.3.1.1 Instream Flow Requirements

The Oroville Facilities are operated to meet minimum flows in the Lower Feather River as established by the 1983 agreement (see above). The agreement specifies that Oroville Facilities release a minimum of 600 cfs into the Feather River from the Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, diversion dam power plant, and the Feather River Fish Hatchery pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April through July period is less than 1,942,000 af (i.e., the 1911-1960 mean unimpaired runoff near Oroville), the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is maintained from October 15 through November 30 to prevent spawning in overbank areas that might become de-watered.

1.3.1.2 Water Temperature Requirements

The Diversion Pool provides the water supply for the Feather River Fish Hatchery. The hatchery objectives are 52°F for September, 51°F for October and November, 55°F for December through March, 51°F for April through May 15, 55°F for last half of May, 56°F for June 1-15, 60°F for June 16 through August 15, and 58°F for August 16-31. A temperature range of plus or minus 4°F is allowed for objectives, April through November.

There are several temperature objectives for the Feather River downstream of the Afterbay Outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook. From May through August, they must be suitable for shad, striped bass, and other warmwater fish.

The National Marine Fisheries Service has also established an explicit criterion for steelhead trout and spring-run Chinook salmon. Memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook and steelhead as a reasonable and prudent measure; DWR is required to control water temperature at Feather River mile 61.6 (Robinson's Riffle in the low-flow channel) from June 1 through September 30. This measure requires water temperatures less than or equal to 65°F on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California ISO anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area (FRSA) contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., 65°F from approximately April through mid May, and 59°F during the

remainder of the growing season). There is no obligation for DWR to meet the rice water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the FRSA contractor's temperature goals.

1.3.1.3 Water Diversions

Monthly irrigation diversions of up to 190,000 (July 2002) af are made from the Thermalito Complex during the May through August irrigation season. Total annual entitlement of the Butte and Sutter County agricultural users is approximately 1 maf. After meeting these local demands, flows into the lower Feather River continue into the Sacramento River and into the Sacramento-San Joaquin Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

1.3.1.4 Water Quality

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from DWR's water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest water quality, which is reasonable, considering all demands being made on the Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, Delta smelt, striped bass, and the habitat of estuarine-dependent species.

1.3.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S. Army Corps of Engineers (USACE). Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by the USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with the USACE.

The flood control requirements are designed for multiple use of reservoir space. During times when flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (point at which specific flood release would have to be made) varies from about 2.8 to 3.2 maf to ensure adequate space in Lake Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry while maintaining adequate flood protection. When the wetness index is high in the basin (i.e., wetness in the

watershed above Lake Oroville), the flood management space required is at its greatest amount to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

2.0 NEED FOR STUDY

Task 3 is a subtask of SP-F5/7, *Evaluation of Fisheries Management on Project Fisheries*. Task 3 fulfills a portion of the FERC application requirements by evaluating potential fish species interactions between fisheries in tributaries upstream from Lake Oroville and the Lake Oroville warmwater and coldwater fisheries. In addition to fulfilling statutory requirements, information collected during this task may be used in developing or evaluating potential Resource Actions.

Performing this study is necessary, in part, because operation of the Oroville Facilities may affect the ability of fish species to migrate between Lake Oroville and its upstream tributaries. The Project could potentially affect biologically relevant hydraulic connectivity between the upstream tributaries and Lake Oroville by altering the timing and magnitude of changes to reservoir surface elevations.

3.0 STUDY OBJECTIVE

3.1 APPLICATION OF STUDY INFORMATION

The results of this analysis will be used to assess potential interactions between fish species in the upstream tributaries and Lake Oroville, and to evaluate the effects of project operations on the potential fish species interactions between fish residing in upstream tributaries and those residing in Lake Oroville.

3.1.1 Department of Water Resources/Stakeholders

The information from this analysis will be used by DWR and the Environmental Work Group (EWG) to evaluate potential on-going effects of project operations by describing the interactions between fish species in the tributaries upstream from Lake Oroville and those residing in the reservoir. Additionally, data collected in this task serves as a foundation for future evaluation and development of potential Resource Actions.

3.1.2 Other Studies

As a subtask of study plan SP-F5/7, *Evaluation of Fisheries Management on Project Fisheries*, Task 3, herein, evaluates potential interactions between the fisheries in the upstream tributaries and those in Lake Oroville. Task 1 evaluates the potential effects of fisheries management on ESA listed fish species, and Task 2 evaluates the achievement of current stocking goals. For further description of Tasks 1 and 2, see SP-F5/7 and associated interim and final reports.

3.1.3 Engineering Exhibits

No modeling results from DWR's Engineering and Operations Group were necessary to complete this study plan report because the focus of SP-F5/7 Task 3, *Evaluation of Interactions Between the Lake Oroville Fishery and Upstream Tributary Fisheries*, utilizes data obtained from fisheries surveys and a review of available literature, and is not a variable that is being modeled by DWR's Engineering and Operations Group.

3.1.4 Environmental Documentation

In addition to Section 4.51(f)(3) of 18 CFR, which requires reporting of certain types of information in the Federal Energy Regulatory Commission (FERC) application for license of major hydropower projects (FERC 2001), it may be necessary to satisfy the requirements of the National Environmental Policy Act (NEPA) as well as the Endangered Species Act (ESA). Because FERC has the authority to grant an operating license to DWR for continued operation of the Oroville Facilities, discussion is required to identify the potential impacts of the project on many types of resources, including fish, wildlife, and botanical resources. In addition, NEPA requires discussion of any anticipated continuing impact from on-going and future operations. To satisfy NEPA

and ESA, DWR is preparing a Preliminary Draft Environmental Assessment (PDEA) to attach to the FERC license application, which shall include information provided by this study plan report.

3.1.5 Settlement Agreement

In addition to statutory and regulatory requirements, SP-F5/7 Task 3 provides information, which may be useful in the development of potential Resource Actions to be negotiated during the collaborative process

4.0 METHODOLOGY

The objective of Task 3 of SP-F5/7 is to evaluate the potential interactions between the Lake Oroville fishery and upstream tributary fisheries. Species compositions of the two fisheries were examined and potential interactions listed and analyzed. Potential interactions included competition for food and habitat, predation, disease transmission, and genetic introgression. A review of available literature was conducted to provide a conceptual evaluation of the effects of these interactions on both fisheries.

4.1 STUDY DESIGN

In order to evaluate potential interactions between the upstream tributary fisheries and the Lake Oroville fishery, species composition data for each fishery were collected. Potential interactions were then identified and available literature was reviewed to determine and evaluate the potential impacts to the two fisheries from these potential interactions. Species composition within the upstream tributaries was provided by data gathered for SP-F3.1 Task 1B, and the species composition of Lake Oroville was determined in SP-F3.1 Task 2A.

The information obtained from the review of available literature was used to evaluate the theoretical potential for interaction and the opportunity for interaction between the fisheries. The theoretical potential for interaction was evaluated based on information characterizing fish habitat and fish distribution as well as describing the ecological roles of fish species. In addition to evaluating the theoretical potential for interaction among fish species based on the material obtained from the literature review, the opportunity for interaction also was evaluated. Evaluation of the opportunity for interaction included consideration of the possibility of interaction among species based on their physical proximity to each other, and on the likelihood of project facilities or operations precipitating an interaction. In other words, if a Lake Oroville resident fish species could theoretically interact with a member of an upstream tributary fishery, the opportunity for interaction was evaluated based on physical proximity of the two species, or the potential for transit to specific locations for potential interactions.

4.2 HOW AND WHERE THE STUDIES WERE CONDUCTED

Evaluation of potential interactions between the Lake Oroville fishery and fisheries in the upstream tributaries were conducted according to the study design described above. Descriptions of how specific interactions were evaluated as well as definitions of the two fisheries and their interactions are presented below.

4.2.1 Evaluation of interactions

Disease transmission, competition, genetic introgression, and predation were the potential interactions evaluated among species of the two fisheries. The potential for disease transmission among fish stocked in Lake Oroville and fish species defined as a

component of the upstream tributaries focused on those diseases investigated by SP-F2, *Evaluation of Project Effects on Fish Disease*, including Infectious Hematopoietic Necrosis (IHN), ceratomyxosis, cold water disease, bacterial kidney disease (BKD), and whirling disease. Because each of these diseases has been shown to infect previously stocked and resident salmonid species in the project area, disease transmission was discussed for all salmonid species rather than by individual species. These diseases are not known to infect non-salmonid species. The potential for competition and predation was discussed and evaluated for each species independently.

4.2.2 Definition of Fishery

4.2.2.1 Lake Oroville Fishery

The Lake Oroville fishery is composed entirely of introduced species, and consists of two components, a coldwater fishery and a warmwater fishery. The coldwater fishery primarily is composed of previously stocked salmonids. Little is known regarding the current abundance of the coldwater fishery in Lake Oroville because it was reported that, during the period in which salmonid stocking continued, the fishery was not self-sustaining, possibly due to insufficient spawning and rearing habitat in the reservoir and accessible portions of the upstream tributaries, and natural and artificial barriers to migration into the upstream tributaries, where sufficient spawning and rearing habitat existed historically (DWR 2001). Analysis of the potential interactions between the Lake Oroville coldwater fishery and the upstream tributary fisheries was performed on those species that were formerly stocked under the DWR stocking program because those species represent the species that could potentially be stocked in the future.

Lake Oroville's warmwater fishery is a self-sustaining fishery that includes four species of black bass, two species of sunfish (*Lepomis cyanellus*, and *L. macrochirus*), two species of crappie (*Pomoxis nigromaculatus* and *P. annularis*), and two species of catfish (*Ictalurus punctatus* and *I. Catus*) (DWR 2001). Spotted bass are considered to be the most significant component of the warmwater fishery in Lake Oroville, in terms of angler effort and regional economic impact. The most abundant bass species in Lake Oroville is spotted bass, followed by largemouth, redeye bass, and smallmouth bass (DWR 2001).

4.2.2.2 Upstream tributary fishery

The upstream tributary fishery is managed for trout. The species present include both rainbow trout and brown trout. Rainbow trout are considered native to the drainage, while brown trout are an introduced species. Although not considered a game fish, hardhead (*Mylopharodon conocephelus*) are included in the upstream tributary fishery because they are a species of management concern. Hardhead was designated as a state species of special concern by DFG in 1995 and is listed as a Class 3 Watch List species, meaning that it occupies much of its native range, but was formerly more widespread or abundant within that range (Moyle et al. 1995). Hardhead are fairly

common in the Sacramento River and lower mainstems of the American and Feather rivers. Hardhead are resident year-round within the Feather River watershed. Therefore, all life stages are present in the Feather River.

4.2.3 Definition of types of interactions

4.2.3.1 Disease Transmission

Disease transmission is defined as the passage of pathogens from an infected host to other individuals of the same or different species. Transmission could occur without causing harm to the new host because transmission is only the transfer of the pathogen and has little to do with manifestation of the disease (i.e., a fish resistant to IHN can still carry the virus and transmit it to other individuals, even though the resistant individual doesn't contract the disease itself).

4.2.3.2 Competition

The most widely used definition of competition reported in available scientific literature is that competition "occurs when a number of animals (of the same or different species) utilize common resources, the supply of which is short. If resources are not in short supply, competition occurs when organisms seeking a particular resource nevertheless harm each other in the process" (Birch 1957).

Prior to the late 1970s it was generally thought that competition played a key role in determining species coexistence. Since that time an alternative view has gained acceptance. The current view suggests that varying ecological conditions coupled with species life history plays a greater role than direct competition for resources in determining species abundance (Allan 1995). For example, two species may coexist in a particular stable environment when both species utilize similar spawning habitat, but there is sufficient spawning habitat such that it is not a limiting factor. In this example, if spawning habitat were removed from the system, competition for that remaining habitat could occur and one species could dominate.

The occurrence of competition is difficult to confirm because there are two possible outcomes to competition between species occupying the same ecological niche: the weaker competitor will become extinct, or one of the species will evolve enough to use a different set of resources (Campbell 1987). Thus, it is difficult to demonstrate the existence of competition because, by its very nature, competition generally does not occur for long periods of time (Campbell 1987). Studies seeking to illustrate the existence of competition must demonstrate an adverse effect on the abundance of individuals of one species due to the abundance of individuals of another species under natural conditions, and they must provide a reasonable explanation of the mechanism by which the effect occurs (Allan 1995). Studies seeking to demonstrate competition generally include manipulation of the population through removal experiments (Allan 1995).

4.2.3.3 Predation

In addition to competition, species may directly interact through predation. Predation occurs when individuals of one species utilize individuals of the same or another species as food items (White and Harvey 2001). Additionally, White and Harvey (2001) suggest that the potential for predation may also have an indirect effect on species interactions because a response to the presence of larger piscivorous fish in pools may cause smaller fish to move to shallower riffles, where increased predation by birds or mammals could occur.

5.0 STUDY RESULTS

5.1 FISH SPECIES COMPOSITION OF LAKE OROVILLE FISHERY

Lake Oroville is managed for a two-story fishery comprised of both warmwater fish that inhabit the warmer epilimnion and littoral zone, and coldwater species that inhabit the cooler hypolimnion zone of the lake. Fisheries management attention in Lake Oroville is focused primarily on salmonids and black bass, and angling for these species represents one of the highest recreational uses of Lake Oroville (DWR 2003b). The Lake Oroville fishery is composed entirely of introduced species.

5.1.1 Coldwater Fishery

The coldwater fishery in Lake Oroville was sustained until 2002 by hatchery stocking. Historical data illustrating stocking activities in Lake Oroville from 1993 through 2002 are presented in Table 5.1-1. From 1993 through 2000, Chinook salmon and brown trout were the only salmonid species stocked in the lake.

Table 5.1-1. Salmonid stocking activities in Lake Oroville (1993 – 2002).

Year	BN-FING	BN-SUB	BN-CAT	ChS-FING	ChS-YEAR	CoS-FING	CoS-YEAR
1993	0	123655	7800	102585	60650	0	0
1994	0	50004	0	104410	55200	0	0
1995	0	65400	0	101922	90001	0	0
1996	8402	80200	0	105841	150435	0	0
1996	0	67403	0	105000	250000	0	0
1998	0	55000	0	106163	352970	0	0
1999	0	50008	0	128750	158290	0	0
2000	0	155700	0	0	28600	0	0
2001	0	0	0	0	0	0	0
2002	0	0	0	0	0	50249	128280
2003	0	0	0	0	0	39222	133570

Legend
 BN = Brown Trout CAT = Catchable ChS = Chinook Salmon CoS = Coho Salmon
 FING = Fingerling SUB = Sub-catchable YEAR = Yearling

Source (DWR 2003c)

During spring 2000, the FRFH experienced an outbreak of IHN. The result of this outbreak was that all inland Chinook salmon on station at the hatchery were destroyed to prevent the spread of the pathogen to the lower Feather River. In July 2000 DWR notified FERC that Chinook salmon stocking would be suspended pending analyses by DFG fish pathologists (DWR 2003c). Based on these analyses, new recommendations were developed by DWR that replaced the inland Chinook salmon stocking program with a coho salmon stocking program. In 2002, DWR purchased 300,000 coho salmon eggs from a private aquaculture facility in Washington. The eggs were hatched and fish were reared at the FRFH, and then stocked in Lake Oroville. A total of 178,529 fish were stocked (50,249 fingerlings and 128,280 yearlings). A total of 172,792 fish were stocked in 2003. DWR proposed stocking 170,000 +/- 10 percent of yearling coho salmon equivalents from 2002 until January 2007 (DWR 2003c). However, a disease

outbreak in the aquaculture facility in Washington prohibited procurement of additional coho salmon eggs in 2004. Additionally, NOAA Fisheries requested that coho salmon stocking be halted pending a risk assessment of the potential effects associated with stocking out-of-basin anadromous salmon above Oroville Dam. The risk assessment will be prepared by DWR and provided to NOAA Fisheries in early 2005. However, NOAA Fisheries has reached a preliminary agreement with DWR to stock approximately 170,000 coded wire tagged coho salmon during 2005. Currently, however, the Lake Oroville coldwater fishery is composed entirely of remnant stocked salmonids.

5.1.1.1 Coho salmon

California coho salmon generally exhibit a three-year life cycle with approximately half of the life cycle spent in freshwater and half in saltwater (Moyle 2002). Coho salmon from central California enter rivers in late December or January and spawn immediately afterwards (Weitkamp et al. 1995). Coho salmon utilize similar spawning habitat to Chinook salmon and steelhead (Moyle 2002), although smaller tributaries reportedly are preferred (DFG 2002).

In hatcheries, coho salmon eggs hatched in about 38 and 48 days at water temperatures of 51.8°F and 48.2°F, respectively (Hassler 1987). After hatching, emergence from the gravel generally occurs in two to seven weeks (Hassler 1987). Juvenile coho salmon show pronounced shifts in habitat with season, especially in California streams (Bell 2001). During winter, juvenile coho salmon select habitats with low water velocity. During spring, juveniles are widely distributed through riffles and runs, and during summer juveniles concentrate in deeper pools or runs (Bell 2001). Juvenile coho salmon tend to rear in cool tributaries in contrast to Chinook salmon, which reportedly stay in warmer main rivers (Moyle 2002). The diet of juvenile coho salmon consists mainly of aquatic insect larvae and terrestrial insects, although small fish are taken when available (Moyle 2002).

Juvenile coho salmon rear for 12 to 24 months before beginning seaward migration as smolts (Moyle 2002). The majority of coho salmon remain at sea for 16 to 18 months before returning to freshwater to spawn (Moyle 2002). Some males may return as “jacks” after only six months at sea (Moyle 2002).

Coho salmon selected for the Lake Oroville stocking program are a domesticated variety, selectively bred for rapid growth and high survival in aquaculture facilities. They have a two-year life cycle and exhibit less propensity to migrate than their wild counterparts (DFG 2001).

5.1.1.2 Chinook salmon

In California, Chinook salmon are found in larger lotic systems from the Oregon border south to the Sacramento-San Joaquin system. The Sacramento-San Joaquin system is the southernmost range for this species in the Pacific Northwest (Moyle 2002). DFG

has planted Chinook salmon in several reservoirs in California, however natural reproduction in landlocked waterways has yet to be documented (Moyle 2002). The life history strategy of Chinook salmon is typically divided into two categories, stream-type and ocean-type. Across the range of Chinook salmon, there is variation within each of these broad categories that gives rise to stocks or runs. Spring-run Chinook salmon exhibit a stream-type life history. Adult spring-run Chinook salmon reportedly enter their natal tributaries as sexually immature fish and hold in the river over the summer while gonadal maturation takes place (DFG 1998; DWR and USBR 2000; Moyle 2002). Historically, spring-run Chinook salmon were reported to have ascended to the very highest streams and headwaters in the lower Feather River watershed (DFG 1998). The Fish Barrier Dam below Oroville Dam now restricts fish passage to historic spawning grounds at higher elevations (DFG 1998). In the lower Feather River, it has been reported that adult spring-run Chinook salmon enter the river from March through June (Sommer et al. 2001), and spawn from August through October (DFG 1998; DWR and USBR 2000; Moyle 2002). Juvenile stream-type salmon tend to rear in fresh water for longer periods of time (>1 year) prior to entering saltwater (Moyle 2002). Fall-run Chinook salmon, considered ocean-type, reportedly enter the lower Feather River in late summer and fall, and typically spawn shortly after arriving on the spawning grounds in late September through December (Sommer et al. 2001; Yoshiyama et al. 1998). Fall-run Chinook salmon stocks spawn in lowland reaches of larger rivers and tributaries. Juvenile ocean-type Chinook salmon tend to rear in fresh water for shorter periods of time (0-12 months) prior to entering saltwater (Moyle 2002). In the lower Feather River, however, it has been reported that both spring-run and fall-run juvenile Chinook salmon emigrate as fry shortly after emergence (DWR 2003a).

5.1.1.3 Rainbow Trout

Rainbow trout are native to the upper Feather River and are the most popular and widely distributed gamefish in California (Moyle 2002). Rainbow trout are currently stocked in the Thermalito Forebay (DWR 2001) and naturally spawning populations of rainbow trout currently exist in the tributaries upstream from Lake Oroville (DFG Website 2003). Rainbow trout were experimentally stocked in Lake Oroville by DFG during the 1970's and 1980's (DWR 2001).

Most wild rainbow trout generally spawn in the spring between February and June (Moyle 2002). Rainbow trout normally spawn by constructing redds (nests) in coarse gravel substrate, 0.5 inches to 5.1 inches in diameter, in the tail of a pool or riffle (Moyle 2002). The number of eggs per female normally depends on size of the fish at spawning but ranges from 200 to 12,000 eggs (Moyle 2002). Most spawning is observed when water temperatures are between 46°F and 52°F in water flowing at from 0.2 ft/sec to 3.6 ft/sec (USFWS 1995). Water temperatures above 63°F reportedly are lethal to developing rainbow trout embryos (Moyle 2002). Eggs normally hatch in three to four weeks with alevins remaining in the gravel for another two to three weeks (Moyle 2002).

For the first year of life, juvenile rainbow trout normally inhabit cool, fast-flowing streams and rivers where riffles predominate over pools and there is cover from riparian vegetation and undercut banks (Moyle 2002). Older rainbow trout tend to move into deeper runs or pools (Moyle 2002). Rainbow trout are reportedly found where daytime water temperatures range from 32°F in the winter to 80.6°F in the summer although 73.4°F is reportedly lethal for unacclimated fish (Moyle 2002).

5.1.1.4 Lake Trout

Lake trout are not native to the Feather River watershed, and were last stocked in Lake Oroville in 1985. A small breeding population is thought to persist in the reservoir (DWR 2003c). The species generally inhabits deep, cold waters of lakes, although it has been reported that in some parts of their range, they live in shallow waters and in rivers. Although generally inhabiting deep areas of lakes, lake trout may move into shallow water in spring and fall in order to feed (Moyle 2002).

Lake trout diet reportedly changes with size as well as with the season (Frantz and Cordone 1970 *in* (Moyle 2002). Small lake trout (less than 13 cm FL) feed mostly on zooplankton. As size increases, increasingly larger prey items are captured including other lake trout and other salmonids (Moyle 2002).

Lake trout are one of the few salmonids that do not construct redds; instead, they broadcast spawn in deep cold water of lakes, generally over rubble and boulders. Spawning generally occurs from mid-September through mid-November. Embryo incubation generally lasts from four to six months and alevins remain among the spawning substrate for one month after hatching (Moyle 2002).

5.1.1.5 Brown Trout

Brown trout are found within the project area and are an introduced species. Brown trout were stocked in Lake Oroville as recently as 2000 (DWR 2001), and normally spawn from November through December in small tributaries (Raleigh et al. 1986). Brown trout over 9 inches in length are active pursuers of large prey, particularly fish (including their own young) and active invertebrates such as crayfish. Adult brown trout largely are bottom-oriented pool dwellers in streams and rivers, but juvenile brown trout reportedly are found equally often in pools and riffles. Lake dwelling brown trout generally spawn in streams, where young rear for several years (Moyle 2002).

5.1.2 Warmwater Fishery

The warmwater fishery of Lake Oroville consists primarily of black bass. Table 5.1-2 shows the results of black bass electrofishing catch-per-unit-effort studies conducted in Lake Oroville on an annual basis from 1994 through 1999.

Based on these survey results, spotted bass are the most prevalent of the black bass species. In addition to black bass, other game fish species occurring in Lake Oroville include two species of sunfish; bluegill and green sunfish; two species of crappie; black crappie and white crappie; and two species of catfish; channel catfish and white catfish.

Table 5.1-2 Lake Oroville black bass electrofish catch per 1000 seconds.

Year	Spotted Bass	Largemouth Bass	Redeye Bass	Smallmouth Bass
1994	56.36	11.47	3.81	4.03
1995	22.50	12.18	2.10	1.96
1996	33.33	5.10	3.05	0.45
1997	42.38	2.72	3.89	0.25
1998	46.79	5.12	2.89	0.17
1999	35.80	3.75	1.76	0.11
Average	39.53	6.72	2.92	1.16

Source (DWR 2003b)

5.1.2.1 Black Bass

None of the black bass species found in the project area are native to California but all are considered important recreational game fish. Redeye bass are the smallest of these species seldom attaining lengths greater than 10 inches (Moyle 2002). Spotted bass attain lengths of 17 inches while both largemouth and smallmouth bass commonly attain lengths of 18 inches (Moyle 2002).

Black bass spawn in the spring from April through June with peak spawning activity in early May. All species prefer a similar spawning habitat and are nest builders. Nest building begins at water temperatures between 59°F and 60.8°F and spawning continues until water temperatures exceed 75.2°F (Moyle 2002). Black bass spawning occurs in water between one and four feet deep near shore and has been observed as deep as 20 feet in clear water (Davis and Lock 1997). In California, with changing reservoir surface levels, spawning has been observed at water depths up to 16.4 feet (Moyle 2002). Black bass species primarily consume insects as juveniles but become increasingly reliant on smaller fish as size increases (Moyle 2002). Of the species of black bass found in Lake Oroville, spotted bass reportedly are the only species that actively seek out streams in which to live during portions of the year. Reservoir resident spotted bass reportedly move into inflowing rivers in the summer and occupy the deep, slow pools and runs (Moyle 2002).

5.1.2.2 Catfish

Neither species of catfish found in Lake Oroville are native to California but both are popular game fish. Adult channel catfish tend to be slightly larger than white catfish (13.8 to 17.7 in vs. 11.8 to 15.7 in (35-45 cm vs. 30-40 cm)) and, when in a river environment, are typically found in faster moving water although both species do well in large reservoirs (Moyle 2002). Both species are frequently observed in Lake Oroville (DWR 2003d).

In California, channel catfish generally spawn from April through June while white catfish spawn slightly later, generally from June through July (Moyle 2002). Spawning channel catfish require water temperatures ranging from 69.8°F to 84.2°F (21°C to 29°C), with 78.8°F to 82.4°F (26°C to 28°C) reported as the optimum water temperature range (Moyle 2002). Channel catfish typically construct nests in cave-like structures (Moyle 2002), many of which have been constructed in Lake Oroville to promote the channel catfish fishery (DWR 1997). In large impoundments nests generally occur among rubble and boulders along protected shorelines at depths between two and four meters (McMahon and Terrell 1982). White catfish construct nests in shallow depressions in sand or gravel near cover or utilize cave sites similar to channel catfish (Moyle 2002).

5.1.2.3 Crappie

Two species of crappie currently inhabit the project area: white crappie and black crappie. Neither species is native to California, but both are popular game fish. Sexually mature crappie are generally 4 to 8 inches (10 to 20 cm) in length and seem to prefer water temperatures ranging from 80.6°F to 84.2°F (27 to 29°C) (Moyle 2002). Black crappie are more frequently observed in Lake Oroville although both species are present (DWR 2003d).

Both species of crappie spawn in late spring and early summer with white crappie tending to spawn a little earlier although there is substantial overlap. Crappie spawn in water temperatures ranging from 62.6°F to 68°F (17°C to 20°C), at a depth between one and seven m (3.3 to 23 feet) (Moyle 2002). Males of both species construct nests utilizing vegetation in shallow depressions in mud or gravel substrate (Moyle 2002).

5.1.2.4 Sunfish

Two species of sunfish, bluegill and green sunfish, are common in the project area. Neither of these species is native to California and both are popular recreational gamefish (Moyle 2002; Wang 1986).

Both species exhibit a similar life history, have a similar lifespan and attain similar sizes. Therefore, the traits of bluegill were used as a basis for analysis of interactions between fisheries. Bluegill are known to live for 8 to 10 years and can attain lengths up to 11.8 inches (Wang 1986). Normally, males construct nests out of debris, leaves, and twigs in fairly shallow water (less than 19.7 in.). Females deposit between 2,000 and 18,000 eggs per nest depending on the size of the female (Wang 1986). Spawning normally occurs as water temperatures exceed 68°F (Wang 1986). In California, spawning occurs throughout the summer with peak spawning occurring in June and July (Wang 1986). Both species generally inhabit small warm streams, ponds, and lake edges (Moyle 2002). Both species are frequently observed in Lake Oroville (DWR 2003d).

5.2 FISH SPECIES COMPOSITION OF UPSTREAM TRIBUTARY FISHERY

Tributaries upstream from Lake Oroville are managed as a trout fishery. Rainbow trout are common in upstream tributaries and are considered native to California. Brown trout also are found in upstream tributaries and are an introduced species. Other trout species such as brook trout and kokanee salmon are stocked in reservoirs upstream from Lake Oroville (Lake Almanor) and may, on occasion, be found in the tributaries between Lake Oroville and Lake Almanor. Due to the rarity with which other salmonid species are found within the upstream tributaries, rainbow and brown trout are considered to be the components of the upstream tributary fishery for purposes of this analysis. In addition, although not a game fish, hardhead are included in this analysis due to their regulatory status as a state species of special concern.

5.2.1 Rainbow trout

Rainbow trout are native to the upper Feather River watershed, and are resident in the tributaries upstream from Lake Oroville. A description of the life history of rainbow trout is presented in Section 5.1.1, above.

5.2.2 Brown trout

Brown trout are an introduced resident in the tributaries upstream from Lake Oroville. A brief description of the life history of brown trout is described in Section 5.1.1, above.

5.2.3 Hardhead

Hardhead are considered a warmwater fish preferring water temperatures above 68°F (Moyle 2002). Hardhead normally spawn in riffles with a gravel substrate (Moyle 2002). Juvenile recruitment suggests that hardhead spawn from May through June in Central Valley streams, but the spawning may extend into August in the foothill streams of the Sacramento- San Joaquin drainage (Moyle 2002).

Juveniles tend to concentrate in shallow water close to stream bank edges (Moyle 2002). Water temperatures where juveniles were observed in the Pit River of California ranged from 61.8°F to 68.4°F (Baltz et al. 1987).

5.3 OPPORTUNITIES FOR INTERACTION

Opportunities for interaction between the upstream tributary fisheries and the Lake Oroville fishery are based on the proximity of the species within each fishery and the ability of the species to transit between the fisheries. From an ecological perspective, Lake Oroville is an artificial environment and the fishery is composed entirely of exotic (introduced) species. While project operations affect Lake Oroville, they have little effect on the upstream tributaries other than allowing or blocking transit between the fisheries based on the surface elevation of the reservoir. Therefore, interactions

between the fisheries are analyzed in the upstream tributaries rather than Lake Oroville. Fish composition in the upstream tributaries was investigated in the SP-F 3.1 Task 2 Report by evaluating the results of survey data collected in upstream tributaries. Figure 5.3-1 shows the results of DWR surveys conducted in Lake Oroville's upstream tributaries in 2002 and 2003.

Table 5.3-1 Numbers of fish captured during sampling efforts, and fish species distribution by tributary and length group in the major tributaries of the upper Feather River.

Species	Length (inches)	South Fork	Middle Fork	North Fork	West Branch	Total
Rainbow Trout	0-5.9	121	5	8	21	155
	6-11.9	32	17	3	47	99
	12<	2	19	0	1	22
Brown Trout	0-5.9	22	0	0	0	22
	6-11.9	6	0	0	6	12
	12<	0	0	0	8	8
Bluegill	0-5.9	9	0	0	0	9
	6-11.9	0	0	0	0	0
	12<	0	0	0	0	0
Green Sunfish	0-5.9	0	0	0	0	0
	6-11.9	0	0	0	0	0
	12<	0	0	0	0	0
Largemouth Bass	0-5.9	0	0	0	0	0
	6-11.9	0	0	0	0	0
	12<	0	0	0	0	0
Redeye Bass	0-5.9	0	0	0	0	0
	6-11.9	0	25	0	0	25
	12<	0	0	0	0	0
Smallmouth Bass	0-5.9	0	0	0	0	0
	6-11.9	0	6	0	0	6
	12<	0	0	0	0	0
Spotted Bass	0-5.9	64	224	0	0	288
	6-11.9	0	33	0	0	33
	12<	1	25	0	0	26
Carp	0-5.9	0	0	0	0	0
	6-11.9	0	0	0	0	0
	12<	0	1	0	0	1
Sacramento Pikeminnow	0-5.9	1	53	0	10	64
	6-11.9	0	22	0	0	22
	12<	0	30	0	1	31
Sucker sp.	0-5.9	34	1	0	0	35
	6-11.9	13	38	1	3	55
	12<	0	45	0	0	45
Sculpin sp.	0-5.9	45	0	1	0	46
	6-11.9	0	0	0	0	0
	12<	0	0	0	0	0
California Roach	0-5.9	0	100	0	1133	1233
	6-11.9	0	0	0	0	0
	12<	0	0	0	0	0
Total		350	644	13	1230	2237

Source (DWR 2004c)

Redeye bass, spotted bass and smallmouth bass all were found in the Middle Fork Feather River during the DWR surveys. Spotted bass were the most numerous of the three species, and appear to be the only component of the black bass species assemblage of Lake Oroville to occur in substantial numbers in upstream tributaries. Spotted bass also were observed in the South Fork Feather River.

Pacific Gas and Electric, in the Poe Hydroelectric Project FERC relicensing reports, reported the results of snorkeling surveys conducted in the Poe Reach of the North Fork Feather River. The Poe Reach of the North Fork Feather River extends downstream from Poe Dam a distance of approximately seven miles to the Poe Powerhouse. The results of these surveys are shown in Table 5.3-2. Surveys reported in the table were conducted in fall 1992, spring 1999, fall 1999, and spring 2000. Results of the surveys were reported by mesohabitat type including pools, runs, pocket water, and riffles. Three different sub-reaches of the Poe reach were sampled in each survey. Rather than reporting raw numbers of fish observed, Table 5.3-2 reports species densities in units of fish per 100 linear feet of survey reach.

Table 5.3-2 Poe Reach snorkel survey results

Pools				
	Fish Density (# fish / 100 ft)			
Species	Fall 1992	Spring 1999	Fall 1999	Spring 2000
Hardhead	0.2	1.8	1.4	0.2
Sacramento Pikeminnow	8.1	3.6	5.7	2.3
Sacramento Sucker	6.4	53.9	10.0	19.9
Rainbow trout	0.9	6.2	1.5	14.8
Smallmouth bass	8.9	1.4	0.0	0.6
Runs				
	Fish Density (# fish / 100 ft)			
Species	Fall 1992	Spring 1999	Fall 1999	Spring 2000
Hardhead	0.0	0.9	1.3	0.2
Sacramento Pikeminnow	0.0	1.1	1.7	1.4
Sacramento Sucker	2.9	54.9	9.1	29.4
Rainbow trout	0.8	18.0	4.1	49.8
Smallmouth bass	3.8	0.7	0.1	0.1
Pocket Water				
	Fish Density (# fish / 100 ft)			
Species	Fall 1992	Spring 1999	Fall 1999	Spring 2000
Hardhead	0.0	0.4	0.0	0.2
Sacramento Pikeminnow	0.0	3.6	0.0	6.0
Sacramento Sucker	4.8	77.0	6.3	27.9
Rainbow trout	4.0	13.5	5.2	30.3
Smallmouth bass	1.6	0.0	0.0	1.1
Riffles				
	Fish Density (# fish / 100 ft)			
Species	Fall 1992	Spring 1999	Fall 1999	Spring 2000
Hardhead	0.0	0.0	0.0	0.0
Sacramento Pikeminnow	0.0	4.3	0.6	2.8
Sacramento Sucker	2.0	24.3	2.2	3.7
Rainbow trout	3.0	12.2	3.6	46.4

Smallmouth bass	1.6	0.0	0.0	0.0
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Source (PG&E 2003)

The most numerous species observed in the Poe Reach of the North Fork Feather River was rainbow trout. Smallmouth bass were found in small numbers and were the only representative of the Lake Oroville fishery observed. There have also been incidental reports of largemouth bass and spotted bass upstream from the Poe Dam on the North Fork (PG&E 2003).

Another factor affecting interactions between the Oroville fishery and the upstream tributary fisheries is the existence of sediment wedges in upstream tributary arms of Lake Oroville. The upper Feather River watershed is producing high sediment yields due to accelerated erosion. Accelerated erosion is a soil loss greater than natural geologic conditions, which can reduce reservoir capacity, degrade water quality, and harm fish and wildlife (DWR 2004e). Extensive sediment deposits, or sediment wedges, have been identified in all four major tributaries of the Feather River. Sediment wedges are subject to periodic exposure events when the reservoir level drops below the elevations at which the wedges occur. Such exposure events potentially disrupt the connectivity between the Lake Oroville fishery and the upstream tributary fishery.

According to DWR (2004e), sediment wedges are dynamic and mobilize differently based on different tributary and reservoir hydrologic conditions. If the reservoir elevation is greater than the uppermost elevation of the wedge, lentic conditions predominate and wedge material does not move appreciably. If the reservoir is lower than the wedge material, fluvial conditions predominate and typical stream processes transport wedge materials downstream. Due to the dynamic nature of the sediment wedges in the upper Feather River/Lake Oroville interface, the frequency, magnitude, and duration of sediment wedge exposure over time is difficult to assess. Sediment deposited in the tributary arms of the reservoir when lake surface elevations are high is subject to reworking and redeposition as reservoir surface elevations fluctuate (DWR 2004e). Lake Oroville sediment wedge locations are shown in Figure 5.3-1.

5.4 DISEASE TRANSMISSION

Disease transmission is primarily a concern in hatcheries, and in areas where there are opportunities for transmission of disease from stocked fish to wild populations. Diseases considered important in the project area include IHN, ceratomyxosis, cold water disease, bacterial kidney disease (BKD) and whirling disease.

5.4.1 IHN

IHN is a major cause of mortality in Chinook salmon, sockeye salmon, and steelhead in fresh water (Noga 1996). Mortality rates as high as 100 percent can occur in these species when less than six months old, while older fish have lower mortality rates and may not display clinical signs of the disease. Clinical signs include lethargy, abdominal distension, and a darkening of abdominal tissue (Noga 1996). Coho salmon, brown

trout, brook trout, and cutthroat trout reportedly are generally considered immune to the disease (Noga 1996). Noga (1996) reported that water temperature plays an important role in IHN epidemics with peak mortality occurring at 50°F, and lower mortality below 50°F. However, Noga (1996) did not report specific percentages of mortalities. Rather, Noga (1996) cited Amend (1970), who reported that no documented mortalities above 59°F have been reported.

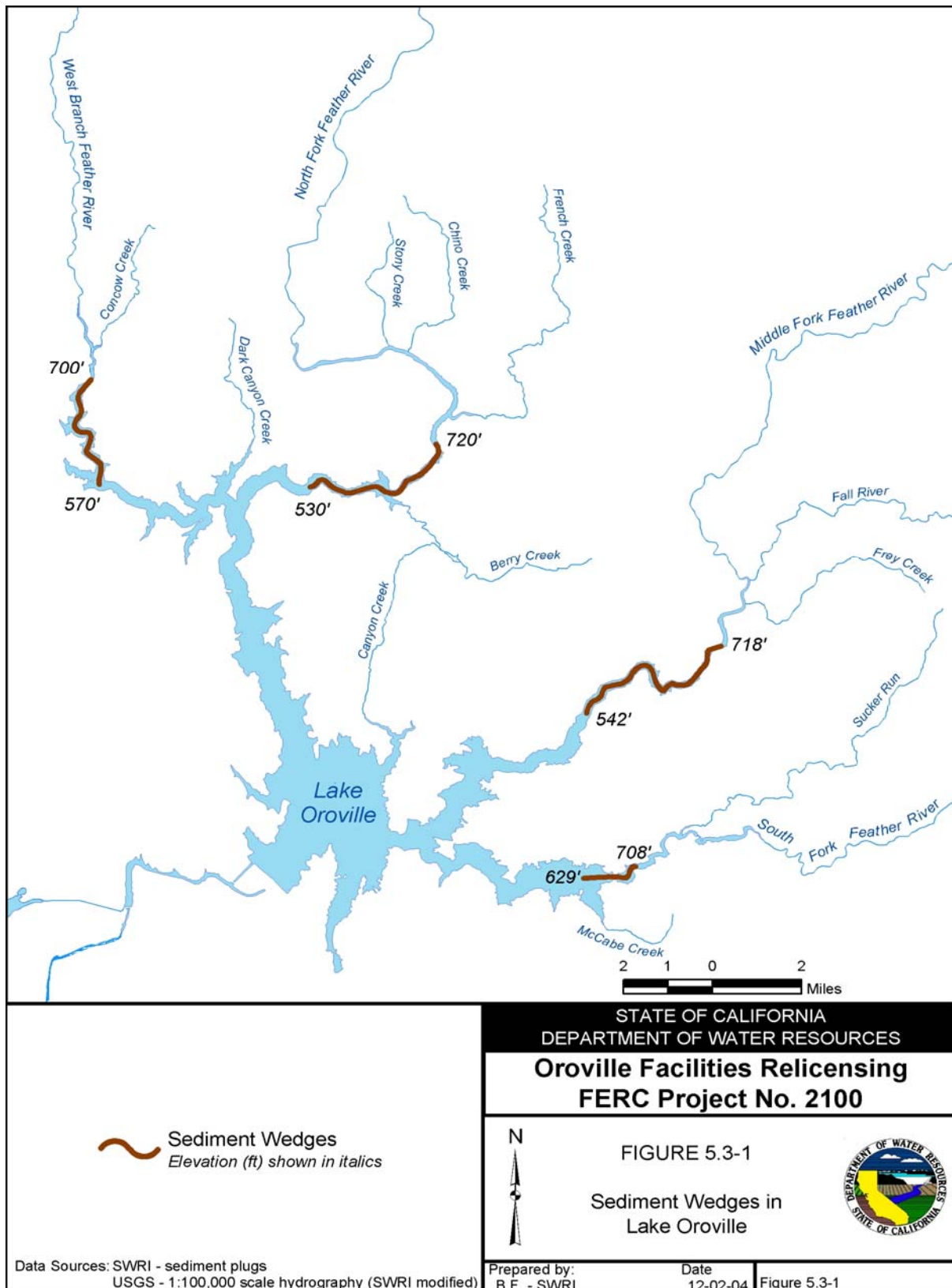


Figure 5.3-1. Lake Oroville Sediment Wedge Locations

During epidemics, IHN readily is transmitted horizontally, or from one individual to another. Ectoparasites (e.g., leeches) and insects reportedly are reservoirs for the virus (Noga 1996). Disinfection and quarantine currently are the only proven methods of controlling IHN epidemics (Noga 1996).

5.4.2 Ceratomyxosis

Ceratomyxosis is caused by *Ceratomyxa shasta*, an endemic myxozoan parasite (Class Myxosporea) that is lethal to many strains of rainbow trout and Chinook salmon. The parasite is prevalent in both the waters of the Thermalito complex and Lake Oroville (DWR 2001). Ceratomyxosis can cause up to 100 percent mortality among juveniles and is also a cause of pre-spawning mortality in adult salmon (Noga 1996). Rainbow trout, Chinook salmon, and chum salmon (*O. keta*) are the species most susceptible to ceratomyxosis, while coho salmon, brown trout and brook trout are less susceptible (Noga 1996). Horizontal transmission of the disease from one individual to another has not been documented and the necessity of an intermediate host is strongly suspected (Noga 1996).

Salmonid populations that are native to rivers where *C. shasta* naturally occurs appear to have developed varying degrees of resistance to infection (Noga 1996). Rainbow trout stocked in the Thermalito Forebay are particularly sensitive to *C. shasta* infections. It is suspected that most stocked rainbow trout not caught in the fishery die of this infection within three months of exposure to the parasite (DWR 2003d).

5.4.3 Cold water disease

Cold water disease is an erosion and ulceration of the skin and is caused by the bacterium *Flavobacterium psychrophilum*, which is known to infect hatchery and wild populations of virtually all salmonids, although coho salmon may be particularly susceptible (Noga 1996). The disease can cause up to 50 percent mortality among juvenile salmonids (Noga 1996), and can be found on clinically normal fish, suggesting that skin damage may be necessary to initiate infection (Holt 1993 *in* (Noga 1996)). The natural reservoir of the bacteria has not been identified but vertical transmission reportedly is considered likely (Noga 1996). Early cases of coldwater disease have been successfully treated with oxytetracycline baths. Wood (1974) and Leon and Bonney (1979) *in* (Noga 1996) suggest that keeping alevins in shallow rather than deep troughs, keeping water flows in incubators low, and inhibiting excessive movement of alevins to prevent abrasions can reduce infections.

5.4.4 BKD

Bacterial kidney disease (BKD) is a chronic disease, economically significant to hatcheries, particularly those raising Pacific salmon, because of its widespread distribution in both freshwater and saltwater environments. The disease is caused by

Renibacterium salmoninarum and only occurs in salmonids. Although fish of any age are susceptible to the disease, losses do not typically occur until the fish are over six months old (Noga 1996). Even fish with severe infections may have no external signs (Noga 1996). The disease is transmitted both horizontally and vertically. Vertical transmission is particularly problematic because the bacterium resides within the yolk and is protected from antiseptics (Evelyn et al. 1985, *in* (Noga 1996).

No proven methods to eradicate BKD infection in fish reportedly exist (Noga 1996). Injection of female broodstock with erythromycin can, however, prevent vertical transmission of the disease (Moffitt 1992). Female broodstock should be injected at least nine days before spawning (Armstrong et al. 1989, *in* (Noga 1996).

5.4.5 Whirling disease

Whirling disease has caused severe damage to rainbow trout populations in Montana and Colorado. Although the parasite causing the disease (*Myxobolus cerebralis*) has been found in California waterways, including the Feather River, no adverse effects on either native or stocked salmonid populations reportedly have been observed (DWR 2004d). Severity of the disease is inversely proportional to the age of the fish at first exposure. Newly hatched fry can suffer 100 percent mortality, while fish over six months old show virtually no clinical signs (Noga 1996).

Currently, hatcheries can only eliminate whirling disease by disinfection, quarantine, and re-population with pathogen free stock. Raising fish in concrete raceways is also a helpful prevention measure because the intermediate host for the organism is the sludge worm (*Tubifex tubifex*) (Noga 1996).

5.5 COMPETITION

No studies directed towards investigating competition among fish species in tributaries upstream from Lake Oroville have been conducted. Based on fish survey results, it appears that if competition exists among the species of the two fisheries, spotted bass are the only Lake Oroville fishery species observed in sufficient quantities to be a potentially substantial competitor with resident species in the upstream tributaries. Specifically, spotted bass could compete with brown trout for food and cover because they are reported to occupy the same types of riverine habitat. In order for competition to exist, however, both species must occupy the same habitat at the same time and require the same resources. In addition, those required resources must be in short supply. It is unclear whether spotted bass and brown trout do require the same resources in the upper Feather River, or whether food or habitat resources are limiting.

Some temporal overlap does exist in the timing of spawning among spotted bass, hardhead and rainbow trout. Spotted bass normally spawn from April through June; rainbow trout spawn from February through June; and hardhead spawn from May through June (Moyle 2002). Brown trout normally spawn in November and December

(Moyle 2002). All three members of the upstream tributary fishery spawn in gravel in relatively fast moving water while spotted bass prefer vegetation and slower moving water.

Juvenile spotted bass, rainbow trout, and brown trout all consume insects as a primary food base. Juvenile hardhead are mainly bottom browsers feeding on invertebrates and aquatic plants (Moyle 2002). Juvenile spotted bass and brown trout are found in similar habitat types while rainbow trout prefer faster moving water (Moyle 2002). Adult spotted bass, rainbow trout, and brown trout also all are piscivores.

Although not recently stocked in Lake Oroville, and not observed in DWR surveys conducted in 2002 and 2003, coho salmon, Chinook salmon, and lake trout could remain a component of the Lake Oroville fishery that could potentially interact with species in the tributary fisheries. Chinook salmon were last stocked in Lake Oroville in during 2000, Coho salmon were last stocked during 2003, and will be stocked again during 2005, and Lake trout were last stocked during 1985, but no mention of observances of the species in the upstream tributaries below the first impassable passage barrier is documented. If inland coho salmon or Chinook salmon migrated to upstream tributaries, they would be expected to utilize similar habitat to rainbow trout for both spawning and juvenile rearing. Likewise, both species feed on insects as juveniles and small fish as they increase in size. Although lake trout reportedly do not generally spawn in rivers and streams, they could potentially migrate into the upstream tributaries. However, competition for spawning habitat is unlikely because lake trout do not construct redds. However, competition with other trout species for cover and food could potentially occur.

Although not recently stocked in Lake Oroville, rainbow trout are still caught in small numbers in the reservoir. It is unclear if the rainbow trout caught in Lake Oroville are resident lake dwellers or if they migrated into the reservoir from the upstream tributaries. However, resident rainbow trout in Lake Oroville that migrate into the upstream tributaries could compete directly with stream resident rainbow and brown trout for food and cover, and could compete directly with rainbow trout for spawning habitat.

Brown trout were last stocked in Lake Oroville in 2002, but a remnant resident population could still exist in the reservoir. Lake Oroville resident brown trout that migrate into the upstream tributaries could compete directly with stream resident rainbow trout and brown trout for food and cover, and could compete directly with stream resident brown trout for spawning habitat.

5.6 PREDATION

Like competition, there have been no studies specifically investigating predation among fish species in Lake Oroville's upstream tributaries. Because spotted bass are the most numerous species considered to be a component of the Lake Oroville fishery that were observed in upstream tributaries, predation by spotted bass may have adverse effects

on members of the upstream tributary fishery. Spotted bass greater than nine inches in length reportedly are known to be predators on other fish species (Moyle 2002).

Because anadromous Chinook salmon and coho salmon do not feed during upstream spawning migrations, and because little is known about inland Chinook salmon and coho salmon feeding habits during spawning migrations, it is unknown what predation effects on resident species could occur from adult inland Chinook salmon. However, it is unlikely that these species would actively prey on resident juveniles during upstream spawning migrations. By contrast, juvenile Chinook and coho salmon could prey on stream resident juveniles. Specifically, yearling stream-type Chinook salmon and yearling coho salmon offspring of stocked Lake Oroville Chinook and coho salmon could prey on recently emerged juvenile brown and rainbow trout.

Lake resident adult brown trout and rainbow trout could prey on stream resident juveniles during upstream spawning migrations. If lake trout migrated into the upstream tributaries, they also could prey on stream resident juveniles. Because lake trout likely would spawn in the Lake Oroville rather than in the upstream tributaries, it is unlikely that they would migrate into the upstream tributaries in substantial numbers, however.

6.0 ANALYSES

6.1 EXISTING CONDITIONS/ENVIRONMENTAL SETTING

Task 3 is a subtask of SP-F5/7, *Evaluation of Fisheries Management on Project Fisheries*, and fulfills a portion of the FERC application requirements by detailing potential effects of project operations on fish species interactions between the Lake Oroville fishery and the Lake Oroville's upstream tributary fishery.

The final report for SP-F3.1 Task 2A, *Fish Species Composition: Lake Oroville, Thermalito Diversion Pool, Thermalito Forebay*, was used to identify the fish species composition of the Lake Oroville fishery. Lake Oroville's upstream tributary fishery is managed for trout and is composed of rainbow and brown trout. Because hardhead have been observed in upstream tributaries, and are a state species of special concern, they are included in the upstream tributary fishery for purposes of this report. The potential for interactions between the two fisheries was determined by upstream tributary fish sampling conducted by DWR and PG&E as reported in the Final Report for SP-F 3.1 Task 1B, *Fish Species Composition in Lake Oroville's Upstream Tributaries*. Connectivity between the fisheries was established by data collected for SP-F3.1 Task 1A, *Assessments of Potential Fish Passage Impediments above Lake Oroville's High Water Mark*.

The DWR and PG&E fish survey data suggest that spotted bass are the only member of the Lake Oroville fishery that occur in sufficient numbers to affect species in the upstream tributary fishery. In addition, spotted bass were only observed in the South and Middle Forks of the Feather River. Relatively large numbers of rainbow trout were observed in all tributaries. Both hardhead and brown trout were observed in relatively low numbers. Hardhead are a native species and are frequently observed in the Feather River from the Fish Barrier Dam downstream to the confluence with the Sacramento River (Moyle 2002). Because hardhead prefer warmer water and generally are found in lowland reaches of rivers in California's Central Valley, their low numbers in Lake Oroville's upstream tributaries are typical (Moyle 2002). Low numbers of brown trout observed during the surveys are more difficult to explain, particularly because they were stocked in Lake Oroville prior to 2001. Because brown trout are an introduced species it is possible that Lake Oroville's upstream tributaries provide only marginal brown trout habitat, or interactions with other stream resident species or lake resident spotted bass could be having a negative impact on brown trout populations.

The existence of sediment wedges in the upstream tributary arms of Lake Oroville potentially blocks migration of species between the two fisheries at certain times. Sediment wedge exposure normally occurs in the fall and winter months when lake surface elevation is low. This timing is coincident with Chinook salmon spawning and could potentially explain why stocked Chinook salmon in Lake Oroville have not been observed in upstream tributaries. Sediment wedges also may block the migration of Chinook salmon and coho salmon into upstream tributaries.

6.2 PROJECT RELATED EFFECTS

6.2.1 Disease Transmission

A review of available literature does not indicate that disease transmission from hatchery-reared fish to wild fish presents a problem, in general, as long as standard hatchery disease prevention and mitigation protocols are followed. These protocols include proper disinfection procedures, periodic examinations by a fish pathologist, and use of certified disease free eggs. Steward and Bjornn (1990) *in* (Perry 1995) concluded that, "in spite of the comparatively high incidence of disease among some hatchery fish stocks, there is little evidence to suggest that diseases or parasites are routinely transmitted from hatchery fish to wild fish."

The FRFH is operated by DFG and maintained by DWR. USFWS provides advice for ongoing operations including disease control and mitigation. In 2000, the Feather River Hatchery upgraded incubation facilities to include equipment for ultraviolet sterilization of a portion of the incoming water supply to minimize infection of eggs and developing embryos. At the hatchery, regularly scheduled examinations by a fish pathologist serve to monitor developing embryos and fish health. These improvements and examinations should serve to keep fish raised at the hatchery disease-free, and should also serve to identify disease outbreaks prior to stocking.

IHN outbreaks at the Feather River Fish Hatchery in 1998, 2000, and 2001 caused DWR to re-evaluate stocking practices in Lake Oroville. The IHN outbreaks resulted in substantial mortality at the hatchery. In 1998, 2000, 2001 and 2002, several million juvenile Chinook salmon died or had to be destroyed as a result of IHN (DWR 2003c). Since 2000, IHN concerns have halted the stocking of Chinook salmon and brown trout in Lake Oroville. DFG fish pathologists examined several species of salmonids and concluded that coho salmon were the least susceptible to IHN (DWR 2003c). If standard hatchery disease prevention and mitigation protocols are followed, including proper disinfection procedures, periodic examinations by a fish pathologist, and use of certified disease free coho salmon eggs, the stocking of coho salmon in Lake Oroville would not be expected to result in increased transmission of IHN to wild Feather River salmonids, including rainbow and brown trout in the upstream tributaries of Lake Oroville.

C. shasta, the parasite that causes ceratomyxosis, is endemic to the Feather River watershed and native salmonids have developed resistance to the infection. Therefore, it does not appear that stocking of *C. shasta*-sensitive salmonids poses a significant threat to native salmonids in the Feather River. One possibility for the low numbers of brown trout observed in the upstream tributaries would be a lack of resistance to ceratomyxosis in a portion of the brown trout population.

Cold water disease, BKD, and whirling disease are the other diseases reported in DWR (2004d) to be of concern in the project area. All of the disease agents causing these diseases are endemic to waters in the Feather River watershed and, therefore, native fish species are exposed to these diseases and disease agents regardless of fish stocking strategies. Normal hatchery operating procedures should minimize the potential for additional spread of these diseases from hatchery stocks to wild stocks.

Overall, the diseases identified in DWR (2004d) as diseases of concern in the upper Feather River are generally endemic to the Feather River watershed, resulting in some level of exposure to native salmonids. However, because of standard hatchery disease prevention and mitigation protocols, and special protocols and facilities for controlling particularly threatening diseases, stocking activities are not likely to substantially increase the incidence of disease in wild fish populations above the existing disease baseline.

6.2.2 Competition

Spotted bass, rainbow trout, and hardhead utilize different habitat types for all life stages. Therefore, little competition for habitat should exist among these species. Brown trout and spotted bass utilize similar habitats for all life stages other than spawning, allowing some competitive interactions between the two species to potentially occur. Competition for food could be one interaction between brown trout and spotted bass, although food resources do not seem to be in short supply. Data gathered for the Final Report for SP-F1, *Evaluation of Project Effects on Non-Fish Aquatic Resources*, indicate that healthy populations of aquatic macroinvertebrates currently exist in the upstream tributaries. Competition for resources between spotted bass and brown trout could, however, partially explain the low numbers of brown trout observed in the DWR upstream tributary fishery surveys. Coho salmon and steelhead (rainbow trout), as well as Chinook salmon and steelhead, are sympatric in many Pacific Coast watersheds suggesting that they utilize different microhabitats within the system. Therefore, it is likely that direct interactions would be limited. Lake trout also could potentially compete with stream resident brown trout and rainbow trout for food and cover, but competition for spawning habitat is unlikely because lake trout do not construct redds. Lake resident brown trout and rainbow trout would compete directly with stream resident brown trout and rainbow trout if lake resident individuals migrated into the upstream tributaries.

6.2.3 Predation

No studies on predation among fish species in Lake Oroville's upstream tributaries have been performed. Therefore, only the potential for predation can be inferred based on species composition.

Moyle and Nichols (1974), report that hardhead are common in areas where both Sacramento pikeminnow and Sacramento sucker are found. Additionally, hardhead are

common where introduced fishes, particularly centrarchids, are few. Because both Sacramento pikeminnow and Sacramento sucker are common in upstream tributaries, the low numbers of hardhead observed could potentially be due to predation by spotted bass.

Predation by adult spotted bass on juvenile brown trout also could be a potential contributing factor in explaining the low numbers of brown trout observed. However, adult brown trout are just as likely to prey on juvenile spotted bass juveniles, so factors other than predation also likely are involved in determining the population dynamics of the two species. Predation by spotted bass on rainbow trout is less likely because juvenile rainbow trout tend to occupy faster moving water than that utilized by spotted bass and brown trout.

No literature on predation of spotted bass on rainbow trout or brown trout could be located, although there is a substantial body of literature on introduced species and their effect on native populations. Fisheries scientists maintain differing views on the impact of introduced species. Some researchers report that introduced species are one of the most important factors causing the extinction or threatened status of native fishes in North America (Lassuy 1995). However, Moyle and Light (1996) suggest that exotic species introductions only present a serious threat in cases where the introduced species are piscivores or have the ability to hybridize with native species.

Because anadromous adult Chinook and coho salmon are known to not feed during upstream spawning migrations, it is unlikely that adult inland Chinook and coho salmon would actively feed during spawning migrations. However, yearling stream-type Chinook salmon and yearling coho salmon could provide a predation risk on resident fry and juvenile salmonids.

Lake trout have been documented to prey upon other salmonids (Moyle 2002). Therefore, lake trout also could potentially prey on stream resident brown trout and rainbow trout if lake trout migrated into the upstream tributaries during the time periods when juvenile brown trout and rainbow trout were present.

Because adult rainbow trout and brown trout are known to be piscivorous, lake resident adult brown trout and rainbow trout could potentially prey upon stream resident juvenile rainbow trout and brown trout. Additionally, stream resident individuals could prey on the progeny of lake resident individuals if lake resident adults spawned in the tributaries.

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